

# HD63487

# Memory Interface and Video Attribute Controller (MIVAC)

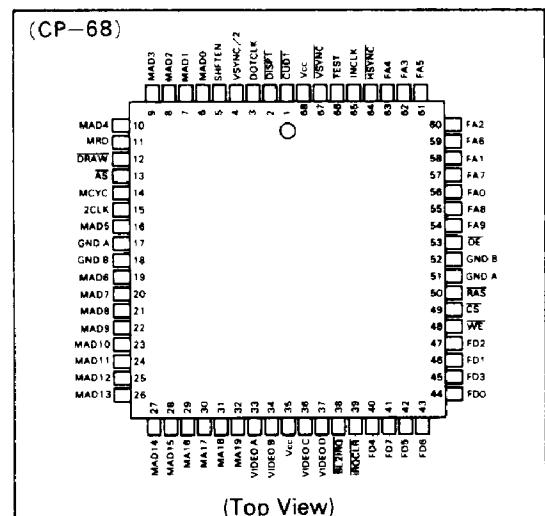
The MIVAC belongs to the HD63484 ACRTC (Advanced CRT Controller) family. It includes peripheral control circuits for graphic display on a chip. Incorporating bus driver circuits and a DRAM interface, the MIVAC allows direct connection to DRAMs with no external circuits. On-chip Parallel/Serial converting shift register generates high speed video signals. Adopting static column mode, fast memory access achieves high throughput in spite of narrow memory data bus. The MIVAC provides most functions required at peripherals of a frame buffer for graphic display constructed with 1 to 4 memory chips, and enables small size graphic system easily. Using the Hi-BiCMOS process, the MIVAC achieves high speed memory access with low power dissipation.

- Generates special clock to drive the ACRTC (asymmetrical 2CLK)
- Input clock divider to generate dot clocks (divided by 1, 2 and 4)
- Supports frame sequential application
  - VSYNC divider and VSYNC/2 output
  - 4 → 2 bit video output multiplexer
- BLINK2 interrupting control (BL2IRQ output)
- CS before RAS refresh
- Direct interface with the ACRTC
- Supports hardware window of ACRTC
- TTL compatible input/output
- Single +5V power supply
- Low power dissipation

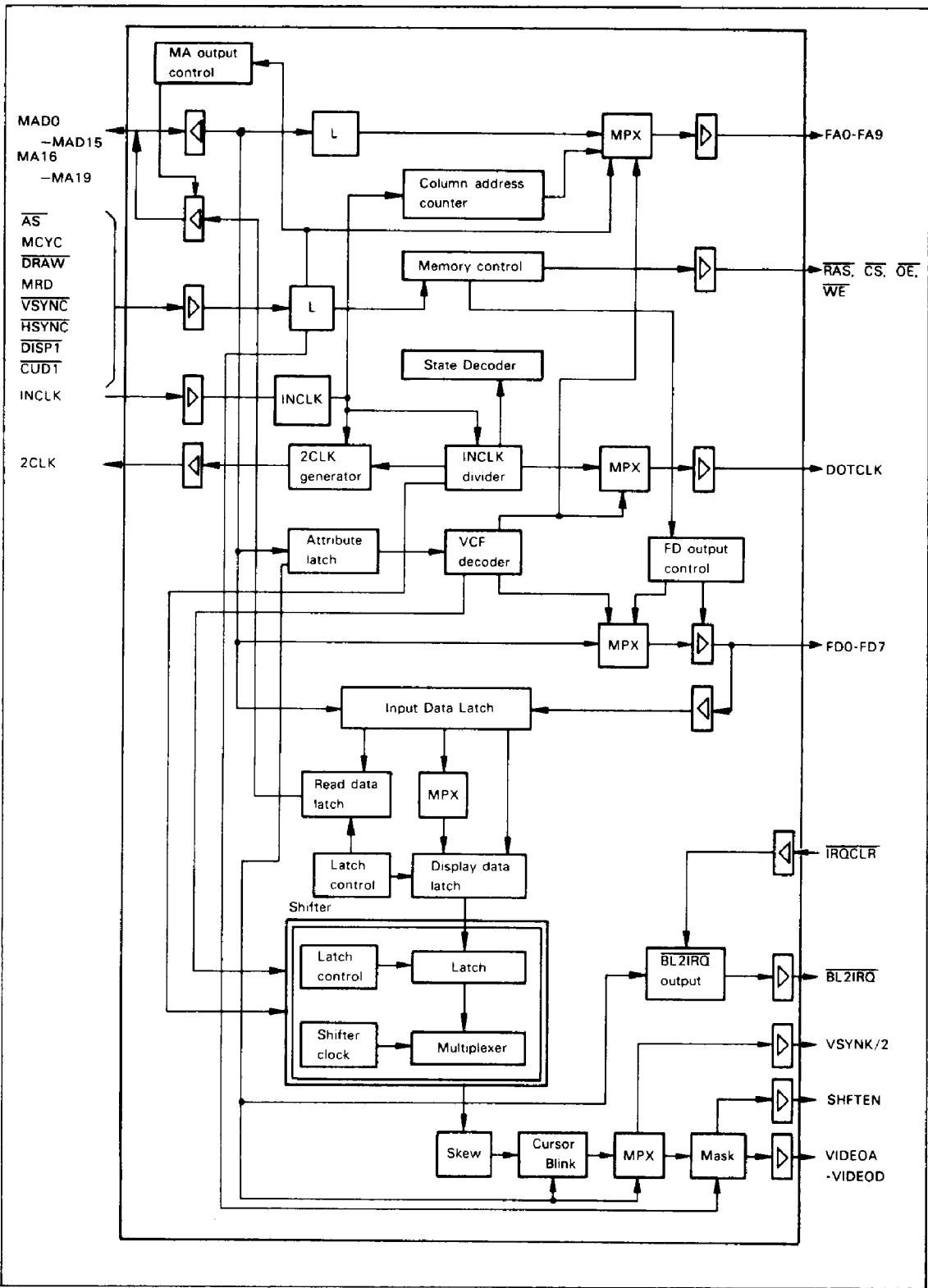
## Features

- Directly connected with 1 to 4 memory devices (x 4 bit organization, static column mode)
- Generates DRAM interface signals: row and column address, RAS, CS, OE, WE and memory data
- Generates high speed video signal: dot rate of 33MHz (max)
- 16 kinds of operation modes by the combination of;
  - 2, 4 and 16 colors (1, 2 and 4 bit/pixel)
  - 8, 16 and 32 dot shift
  - Single/Dual access
  - 1, 2 and 4 chips memory
- Blinking block cursor display
- Memory variation: 256kx4 static column mode DRAM

## Pin Assignment



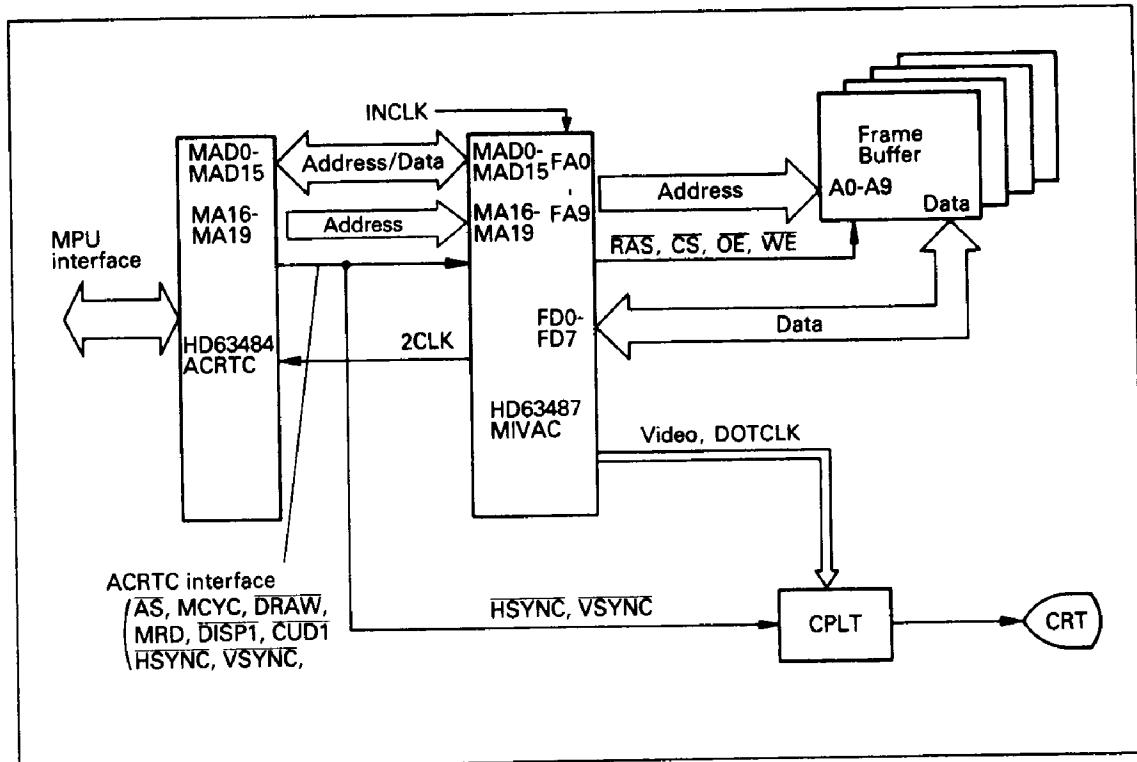
## Block Diagram



## Function Table

Mode	Attribute code (ACRTC)				MCYC	Access Mode	Memory Chip	Bit/ Pixel	Shifted Dot	DOTCK Division
	MAD3	MAD2	MAD1	MAD0						
0	0	0	0	0	1	Single	1	1	16	1
1	0	0	0	1	1	Single	1	2	8	2
2	0	0	1	0	1	Single	1	4	4	4
3	0	0	1	1	1	Single	2	2	16	1
4	0	1	0	0	1	Single	2	4	8	2
5	0	1	0	1	1	Single	4	4	16	1
6	0	1	1	0	1	Dual	1	1	16	2
7	0	1	1	1	1	Dual	1	2	8	4
8	1	0	0	0	1	Dual	2	1	32	1
9	1	0	0	1	1	Dual	2	2	16	2
A	1	0	1	0	1	Dual	2	4	8	4
B	1	0	1	1	1	Dual	4	2	32	1
C	1	1	0	0	1	Dual	4	4	16	2
D	1	1	0	1	2	Single	1	2	32	1
E	1	1	1	0	2	Single	1	4	16	2
F	1	1	1	1	2	Single	2	4	32	1

## System Application Example



**CRT Display Interface**

**Dot Clock (DOTCLK):** The MIVAC internally divides INCLK by 1, 2 or 4 to generate the DOTCLK output. DOTCLK division ratio depends on VCF0-VCF3 of attribute code.

**Video Outputs (VIDEOA-VIDEOD):** VIDEOA-VIDEOD are the four bits output from the MIVAC's parallel-to-serial conversion shift register. They are supplied during a display period specified by the display signal (DISP). Which outputs are usable depends on the attribute code (VCF0-VCF3).

**Shift Enable (SHFTEN):** SHFTEN is active

high output. This output indicates the active display period of the screen.

**Vertical Sync Divide-by-2 (VSYNC/2):** VSYNC/2 output is VSYNC signal from the ACRTC divided by two.

**Others**

**BLINK2 Interrupt (BL2IRQ):** This output is set by BLINK2 (MA19) of the attribute code. BL2IRQ is low when BLINK2 is high.

**BLINK2 Interrupt Clear (IRQCLR):** This input clears the BL2IRQ signal. When IRQCLR is low, BL2IRQ is clear and high.

**Pin Description**

Signal	Description	Pin No.
V <sub>cc</sub>	Power	68
V <sub>cc</sub>	Power	35
V <sub>ss</sub>	Logic ground	52
V <sub>ss</sub>	Logic ground	51
V <sub>ss</sub>	Logic ground	18
V <sub>ss</sub>	Logic ground	17
2CLK	Output clock to the ACRTC	15
MCYC	Memory cycle input from the ACRTC	14
DRAW	Draw input from the ACRTC	12
MRD	Memory read input from the ACRTC	11
AS	Address strobe input from the ACRTC	13
MAD0	Multiplex frame buffer address/data to/from ACRTC	6
MAD1	Multiplex frame buffer address/data to/from ACRTC	7
MAD2	Multiplex frame buffer address/data to/from ACRTC	8
MAD3	Multiplex frame buffer address/data to/from ACRTC	9
MAD4	Multiplex frame buffer address/data to/from ACRTC	10
MAD5	Multiplex frame buffer address/data to/from ACRTC	16
MAD6	Multiplex frame buffer address/data to/from ACRTC	19
MAD7	Multiplex frame buffer address/data to/from ACRTC	20
MAD8	Multiplex frame buffer address/data to/from ACRTC	21
MAD9	Multiplex frame buffer address/data to/from ACRTC	22
MAD10	Multiplex frame buffer address/data to/from ACRTC	23
MAD11	Multiplex frame buffer address/data to/from ACRTC	24
MAD12	Multiplex frame buffer address/data to/from ACRTC	25
MAD13	Multiplex frame buffer address/data to/from ACRTC	26
MAD14	Multiplex frame buffer address/data to/from ACRTC	27
MAD15	Multiplex frame buffer address/data to/from ACRTC	28
MA16	Memory address line 16 from the ACRTC	29
MA17	Memory address line 17 from the ACRTC	30
MA18	Memory address line 18 from the ACRTC	31
MA19	Memory address line 19 from the ACRTC	32



## Pin Description (cont)

Signal	Description	Pin No.
HSYNC	Horizontal sync input from the ACRTC	64
VSYNC	Vertical sync input from the ACRTC	67
VSYNC/2	Vertical sync divide-by-2 output	4
CUD1	Cursor control input from the ACRTC	1
DISP1	Display input from the ACRTC	2
RAS	Row address strobe output to DRAM	50
CS	Chip select output to DRAM	49
WE	Write enable output to DRAM	48
OE	Output enable output to DRAM	53
FA0	Frame buffer (memory) address output 0	56
FA1	Frame buffer (memory) address output 1	58
FA2	Frame buffer (memory) address output 2	60
FA3	Frame buffer (memory) address output 3	62
FA4	Frame buffer (memory) address output 4	63
FA5	Frame buffer (memory) address output 5	61
FA6	Frame buffer (memory) address output 6	59
FA7	Frame buffer (memory) address output 7	57
FA8	Frame buffer (memory) address output 8	55
FA9	Frame buffer (memory) address output 9	54
FD0	Frame buffer data input/output line 0	44
FD1	Frame buffer data input/output line 1	46
FD2	Frame buffer data input/output line 2	47
FD3	Frame buffer data input/output line 3	45
FD4	Frame buffer data input/output line 4	40
FD5	Frame buffer data input/output line 5	42
FD6	Frame buffer data input/output line 6	43
FD7	Frame buffer data input/output line 7	41
INCLK	Main timing clock input	65
DOTCLK	DOT clock output to video circuit	3
VIDEOA	Video A output	33
VIDEOB	Video B output	34
VIDEOC	Video C output	36
VIDEOD	Video D output	37
TEST	Test pin input	66
SHFTEN	Shift enable output	5
BL2IRQ	BLINK2 interrupt output	38
IRQCLR	BLINK2 interrupt clear input	39

## Operation

## Basic operating clock

Output signals from MIVAC define INCLK which inputs to MIVAC as a basic operating clock, and input signals to MIVAC define 2CLK which is output from MIVAC as well. 2CLK, the basic operating clock of ACRTC which is output from MIVAC, is generated from INCLK. In order to save the memory access time, 2CLK is configurated unsymmetrically between the first half and the latter half of cycle times as shown below.

## Frame buffer control

MIVAC uses the DRAM of the static column mode as a memory for the frame buffer, and reduces the number of memory used for the frame buffer by accessing the memory several times per memory cycles. Using one, two, and four DRAMs respectively, MIVAC can deal with various kinds of applications. Figure 2 shows the connection of MIVAC to the DRAM.

To control these DRAMs, MIVAC generates RAS, CS, OE and WE. And it outputs the row and the column address as the ones for DRAM, adapting to the timing of RAS and CS.

The Drawing Read cycle is shown in figure 3, the Drawing Write cycle in figure 4, the Display Read cycle in figure 5 and 6, and CS before RAS Refresh cycle in figure 7 respectively.

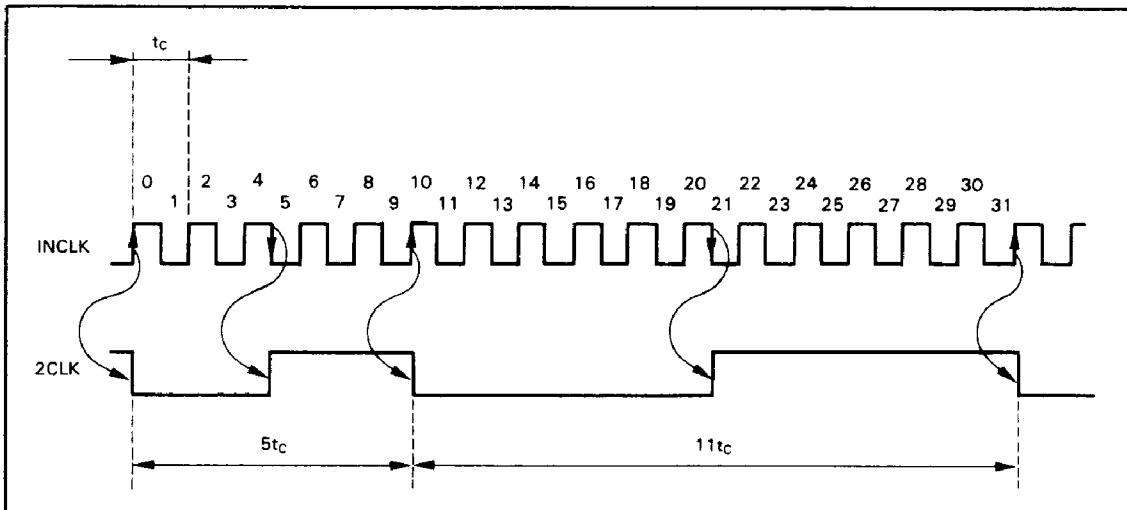
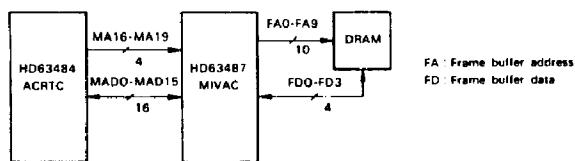
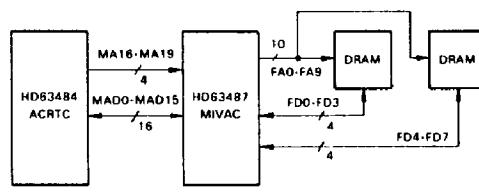


Figure 1. 2CLK Output Timing



(a) 1 memory chip



(b) 2 memory chips

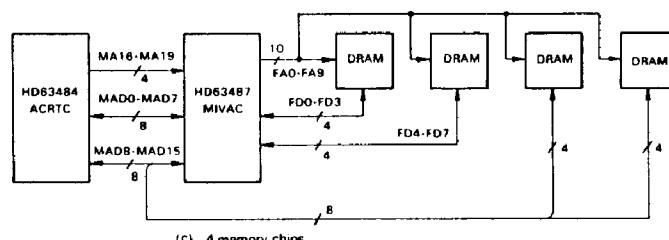


Figure 2. Frame Buffer Connections

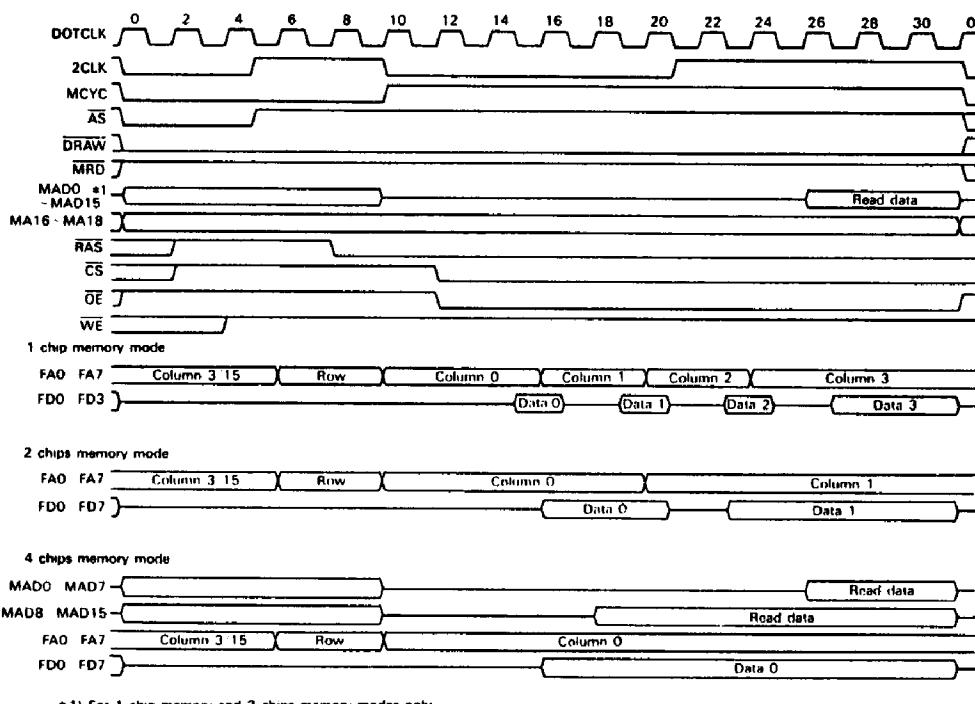


Figure 3. 1MCYC Drawing Read Cycle

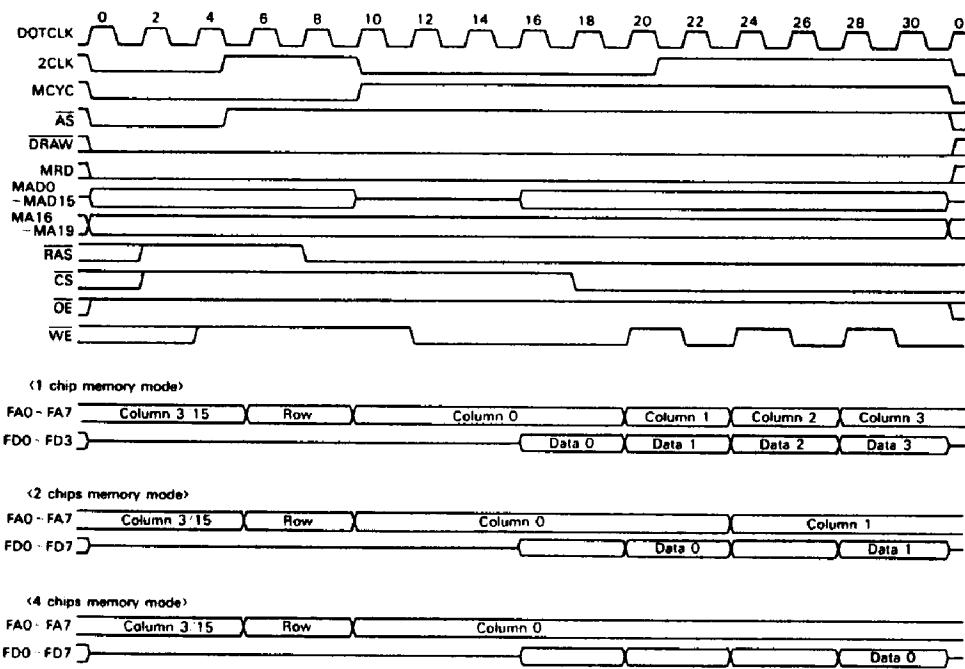


Figure 4. 1MCYC Drawing Write Cycle



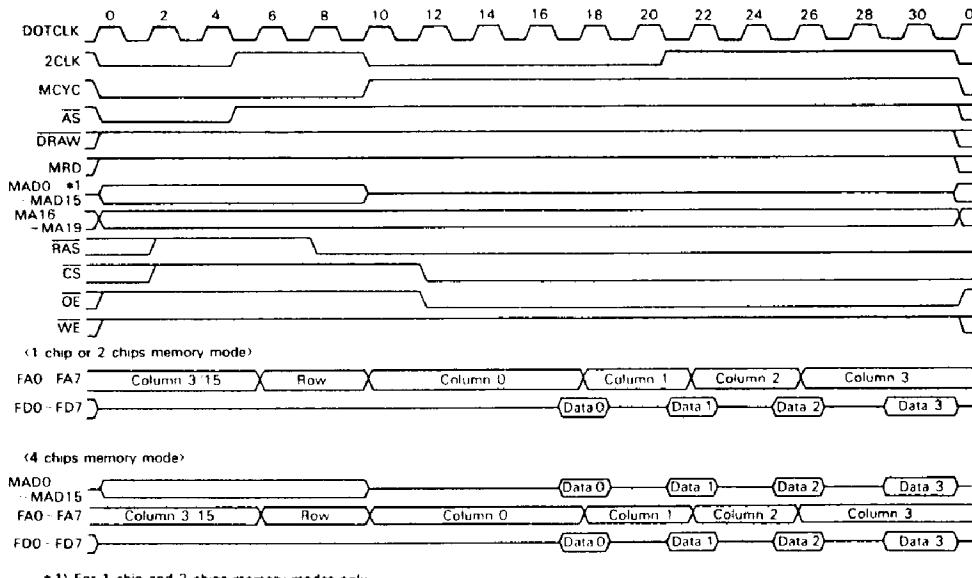


Figure 5. 1MCYC Display Read Cycle

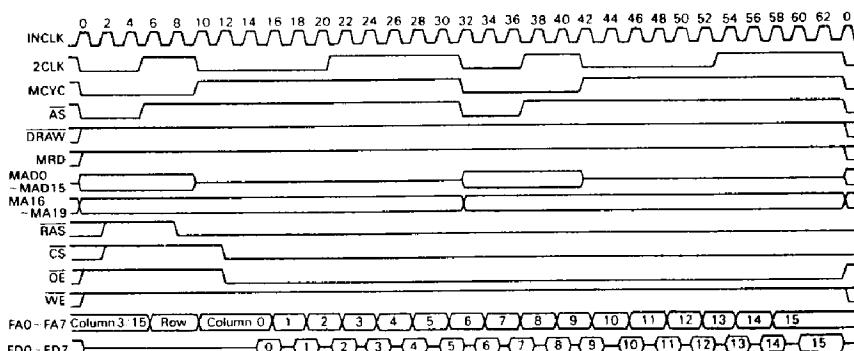


Figure 6. 2MCYC Display Read Cycle

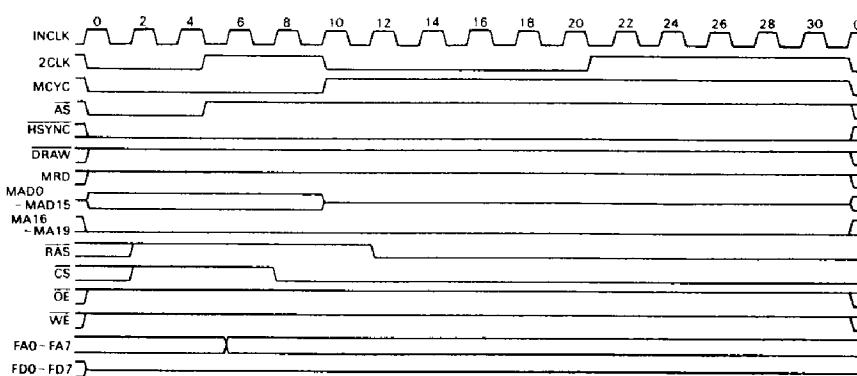


Figure 7. CS Before RAS Refresh Cycle



## Data Transfer

The MIVAC contain control circuits for bidirectional transfer between the ACRTC and frame buffers. To transfer data, the MIVAC receive the ACRTC's memory cycle (MCYC), memory read (MRD), draw (DRAW) and address strobe (AS) signals.

The MIVAC recognize a nondisplay cycle when DRAW is low. In nondisplay cycles the data transfer direction is determined by the memory read signal (MRD). MRD high signifies a read cycle to transfer data from frame buffers to the ACRTC. MRD low signifies a write cycle to transfer data from the ACRTC to the frame buffers. Timing for the data transfer is determined by the MCYC input. When MCYC is high, frame buffers or the ACRTC three-state output buffers are enabled for transfer.

**Drawing Write Cycle:** The MIVAC recognize a drawing write cycle when both DRAW and MRD are low.

**Drawing Read Cycle:** The MIVAC recognize a drawing read cycle when DRAW is low and MRD is high.

When MCYC is high during this cycle, the MIVAC enable the data buffer (MAD0-MAD15) for the ACRTC and output a word from the frame buffers.

## Video signal generation

MIVAC converts the parallel display data, which is output from the frame buffer, to serial in the internal shift register, and outputs the display data from VIDEOA-VIDEOD pins after making it simultaneous with DOTCLK. As the pins for VIDEOA-VIDEOD are determined by the graphic bit mode, they must be connected to CRT carefully. Table 1 shows the relation between the mode and the used pins.

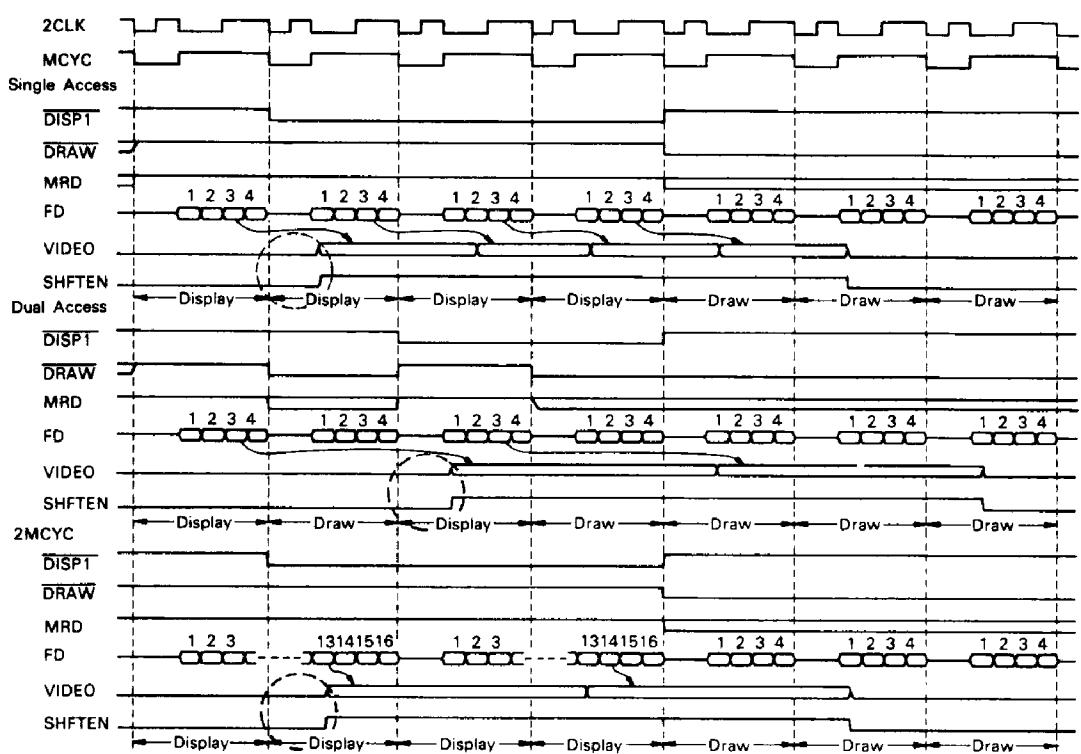
Figure 8 shows the relation between the memory access and the video output.

**Table 1. Operation Mode and Video Outputs**

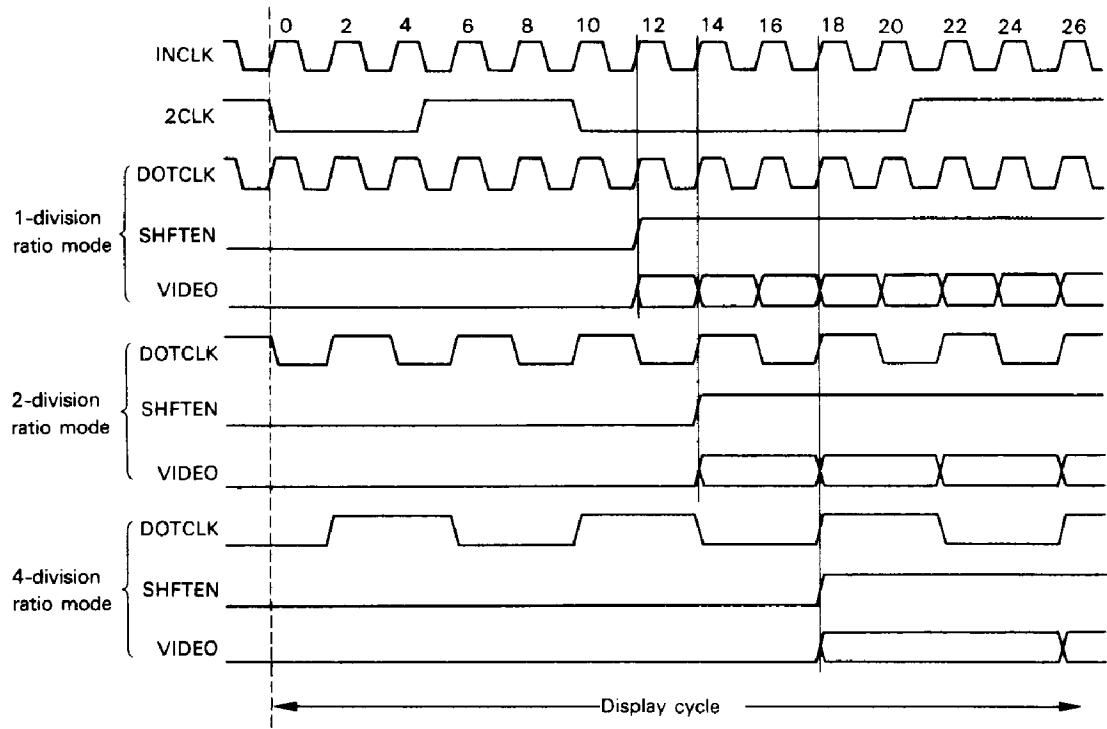
Mode	Graphic bit mode (bit/pixel)	Display colors (or Gray scale)	VIDEOA	VIDEOB	VIDEOC	VIDEOD
0	1	Monochrome (2)	○	×	×	×
1	2	4 (4)	○	○	×	×
2	4	16 (16)	○	○	○	○
3	2	4 (4)	○	○	×	×
4	4	16 (16)	○	○	○	○
5	4	16 (16)	○	○	○	○
6	1	Monochrome (2)	○	×	×	×
7	2	4(4)	○	○	×	×
8	1	Monochrome (2)	○	×	×	×
9	2	4 (4)	○	○	×	×
A	4	16 (16)	○	○	○	○
B	2	4 (4)	○	○	×	×
C	4	16 (16)	○	○	○	○
D	2	4 (4)	○	○	×	×
E	4	16 (16)	○	○	○	○
F	4	16 (16)	○	○	○	○

○ : Available

× : Not available



Following figure shows the detailed timing of SHFTEN and VIDEO output at sign of  $\odot$ .



**Figure 8. Display Timing (Single Access, Dual Access, 2MCYC)**

## Attribute Control Codes

The MIVAC sets colors, the number of shift bits, and access mode when it receives attribute codes and blink information from the ACRTC. The ACRTC outputs 20 bits of attribute control codes (MAD0 to MAD15, MA16

and MA19) during the attribute control code output cycle (figure 9). This information includes user-definable codes and blink control codes (figure 10).

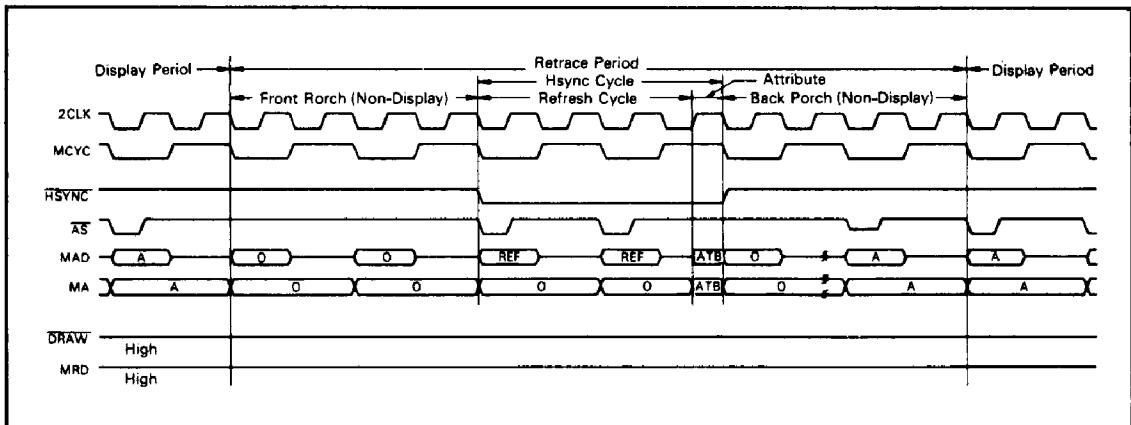


Figure 9. DRAM Refresh and Attribute Code Output Timing (Single Access Mode)

Signal	Attribute Control Codes	
MA19	BLINK2	BL2IRQ output
MA18	BLINK1	Graphic cursor cursor blinking
MA17	SPL2	
MA16	SPL1	
MAD15	HZ3	
	{	
MAD12	HZO	MIVAC does not use
MAD11	HSD3	
	{	
MAD8	HSD0	
MAD7	MUXEN	Video multiplex output enable
MAD6	VMD	Frame buffer depth
MAD5	CUR1	
MAD4	CUR0	Color of graphic cursor
MAD3	VCF3	
MAD2	VCF2	MIVAC operating modes
MAD1	VCF1	
MAD0	VCF0	Attribute Control Codes

Figure 10. Attribute Control Codes

**VCF0—VCF3 (MAD0—MAD3)**

VCF0 to VCF3 (MAD0 to MAD3) define sixteen basic operating modes as shown in the tables 2 and 3.

**Table 2. Operating Modes**

Mode	ACRTC Attribute Code Setting				Screen Configuration (Dots × Rasters)	Frame Buffer (Bytes)	ACRTC Operating Frequency (MHz)			Access Mode	Memory Chips	Color Grade- ation	DOTCLK			
	VCF3	VCF2	VCF1	VCF0			Memory Access	4.13	480 ns/ 4 times				16	Division Ratio	Maximum Frequency (MHz)	
0	0	0	0	0	640×200, 350, 400, 480	512k/128k				Single access mode	1	B&W	16	1	33	
1	0	0	0	1	640×200, 480×240, 320×200, 240						4	8	2	16.5		
2	0	0	1	0	320×200, 240 256×192						16	4	4	8.25		
3	0	0	1	1	640×200, 350, 400, 480	1M/256k				2	4	16	1	33		
4	0	1	0	0	640×200, 480×240, 320×200, 240						16	8	2	16.5		
5	0	1	0	1	640×200, 350, 400, 480	2M/512k				4		16	1	33		
6	0	1	1	0	640×200, 480×240, 320×200, 240	512k/128k				Dual access mode 0	1	B&W	2	16.5		
7	0	1	1	1	320×200, 240 256×192						4	8	4	8.25		
8	1	0	0	0	640×200, 350, 400, 480	1M/256k				2	B&W	32	1	33		
9	1	0	0	1	640×200, 480×240, 320×200, 240						4	16	2	16.5		
A	1	0	1	0	320×200, 240 256×192						16	8	4	8.25		
B	1	0	1	1	640×200, 350, 400, 480	2M/512k				4	4	32	1	33		
C	1	1	0	0	640×200, 480×240, 320×200, 240						16	16	2	16.5		
D	1	1	0	1	640×200, 350, 400, 480	512k/128k				960 ns/ 16 times	Single access mode	1	4	32	1	33
E	1	1	1	0	640×200, 480×240, 320×200, 240						16	16	2	16.5		
F	1	1	1	1	640×200, 350, 400, 480	1M/256k				2		32	1	33		

**Table 3. Dot Clock Frequency Range**

Mode	Frequency
0, 3, 5, 8, B, D, F	33—11 MHz
1, 4, 6, 9, C, E	16.5—5.5 MHz
2, 7, A	8.25—2.75 MHz

**MCYC Fetch:** The MCYC fetch defines the number of cycles.

- 1: One, two, or four memories
- 2: One or two memories

**Access Mode:** The MIVAC supports single- and dual-access 0 modes.

- 1: Single access/dual access 0
- 2: Single access

**Memory Chips:** The MIVAC can connect one, two, or four memory chips.

1 chip : connect FD0 to FD3 to data bus  
2 chips: connect FD0 to FD8 to data bus  
3 chips: connect FD0 to FD7 to low-order 8 bits, and MAD8 to MAD15 to high-order 8 bits of data bus.

**Bit/Pixel:** The MIVAC can display:

- 1 bit/pixel (B&W)
- 2 bits/pixel (4 colors)
- 4 bits/pixel (16 colors)

**Dot Shift:** The MIVAC can shift by 4, 8, 16, or 32 dots.

**DOTCLK Division:** The MIVAC can divide

the INCLK frequency by 1, 2, or 4 depending on the number of shifted dots and access modes.

## CUR0 and CUR1 (MAD4 and MAD5)

CUR0 and CUR1 set the cursor color (table 4).

## VMD0 (MAD6)

VMD0 selects memory chips (table 5).

## MUXEN (MAD7)

MUXEN selects the multiplex video output. Multiplexing is defined by MUXEN and VSYNC/2 (table 6). VSYNC/2 is obtained by dividing VSYNC from the ACRTC by 2.

Note: VIDEOD is not multiplexed.

## BLINK1 (MA18)

BLINK1 defines the blinking of cursor (table 7).

## BLINK2 (MA19)

BLINK2 controls BL2IRQ output. When BLINK2 is 1, BL2IRQ is asserted (low).

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**Table 4. Cursor Color**

<b>CUR1</b>	<b>CUR0</b>	<b>Cursor Color</b>
0	0	Black (VIDEOA to VIDEOD = 0)
0	1	White (VIDEOA to VIDEOD = 1)
1	0	Color specified by each bit (VIDEOA to VIDEOD) is inverted
1	1	Color specified by each bit (VIDEOA to VIDEOC) is inverted. (VIDEOD is not changed.)

**Table 5. Memory Chips**

<b>VMD</b>	<b>Memory chips</b>
0	256k words × 4 bit DRAM
1	1M words × 4 bit DRAMs

**Table 7. Cursor Blink**

<b>BLINK1</b>	<b>Cursor</b>
0	No blinking
1	Blinking

**Table 6. Video Multiplex**

<b>MUXEN</b>	<b>VSYNC/2</b>	<b>VIDEOA</b>	<b>VIDEOB</b>
0	0	A	B
	1	A	B
1	0	A	B
	1	C	D



## Absolute Maximum Ratings

Item	Symbol	Rating	Unit
Supply Voltage	$V_{CC}$ (Note)	−0.3 to +7.0	V
Input Voltage	$V_{in}$ (Note)	−0.3 to $V_{CC} + 0.3$	V
Output Voltage	$V_{out}$ (Note)	5.5	V
Operating Temperature	$T_{opr}$	0 to +70	°C
Storage Temperature	$T_{stg}$	−55 to +150	°C

Note: This value is in reference to  $V_{SS} = 0$  V.

## Recommended Operating Conditions

Item	Symbol	Min	Typ	Max	Unit
Supply Voltage	$V_{CC}$ (Note)	4.75	5.00	5.25	V
Input "Low" Level Voltage	$V_{IL}$ (Note)	0	—	0.7	V
Input "High" Level Voltage	$V_{IH}$ (Note)	2.2	—	$V_{CC}$	V
Operating Temperature	$T_{opr}$	0	25	70	°C

Note: This value is in reference to  $V_{SS} = 0$  V.

## Electrical Characteristics

### DC Characteristics

( $V_{CC} = 5.0$  V ± 5%,  $V_{SS} = 0$  V,  $T_a = 0$  to +70°C unless otherwise noted.)

Item	Symbol	Min	Max	Unit	Test Condition
Input "High" Level Voltage	All Inputs $V_{IH}$	2.2	$V_{CC}$	V	
Input "Low" Level Voltage	All Inputs $V_{IL}$	−0.3	0.7	V	
Input Clamp Voltage	All Inputs $V_i$	—	−1.5	V	$V_{CC} = 4.75$ V $I_{IN} = −18$ mA
Output "High" Level Voltage	All Outputs $V_{OH}$	2.7	—	V	$V_{CC} = 4.75$ V $I_{OH} = −400$ $\mu$ A
Output "Low" Level Voltage	All Outputs $V_{OL}$	—	0.5	V	$V_{CC} = 4.75$ V $I_{OL} = 8$ mA
"High" Level Input Current	All Inputs $I_{IH}$	—	20	$\mu$ A	$V_{CC} = 5.25$ V $V_i = 2.7$ V
"Low" Level Input Current	All Inputs $I_{IL}$	—	−400	$\mu$ A	$V_{CC} = 5.25$ V $V_i = 0.4$ V
Short Circuit Output Current	All Outputs $I_{OS}$	−40	−120	mA	$V_{CC} = 5.25$ V
Supply Current	$I_{CC}$	—	120	mA	$V_{CC} = 5.25$ V



**AC Characteristics**(V<sub>CC</sub> = 5.0 V ± 5%, V<sub>SS</sub> = 0 V, Ta = 0 to +70°C unless otherwise noted.)

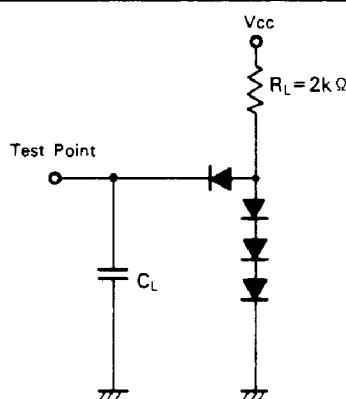
No.	Item	Symbol	Reference Figure #	Min	Max	Unit
1	INCLK Cycle Time	t <sub>C</sub>	11	30	—	ns
2	INCLK High Level Pulse Width	t <sub>HW</sub>	11	12	—	ns
3	INCLK Low Level Pulse Width	t <sub>LW</sub>	11	12	—	ns
4	INCLK Rise Time	t <sub>R</sub>	11	—	5	ns
5	INCLK Fall Time	t <sub>F</sub>	11	—	5	ns
6	2CLK Delay Time	t <sub>2CLKD</sub>	11	—	15	ns
7	MCYC Setup Time	t <sub>MCYCS</sub>	11	10	—	ns
8	MCYC Hold Time	t <sub>MCYCH</sub>	11	0	—	ns
9	HSYNC Setup Time	t <sub>HSS</sub>	11	15	—	ns
10	HSYNC Hold Time	t <sub>HSH</sub>	11	0	—	ns
11	DISP1 Setup Time	t <sub>DISPS</sub>	11	20	—	ns
12	MRD Setup Time	t <sub>MRDS</sub>	11	15	—	ns
13	MRD hold Time	t <sub>MRDH</sub>	11	5	—	ns
14	DRAW Setup Time	t <sub>DRAWS</sub>	11	15	—	ns
15	DRAW Hold Time	t <sub>DRAWH</sub>	11	5	—	ns
16	AS Setup Time	t <sub>ASS</sub>	11	20	—	ns
17	AS Pulse Width	t <sub>ASW</sub>	11	25	—	ns
18	Memory Address Setup Time	t <sub>AS</sub>	11	25	—	ns
19	Memory Address Hold Time	t <sub>AH</sub>	11	0	—	ns
20	CUD1 Setup Time	t <sub>CUDS</sub>	11	5	—	ns
21	VSYNC Setup Time	t <sub>VSS1</sub>	17	5	—	ns
22	Attribute Code Delay Time	t <sub>AACS</sub>	20	—	100	ns
23	Attribute Code Hold Time	t <sub>AASH</sub>	20	5	—	ns
24	RAS Delay Time	t <sub>RSD</sub>	11	—	15	ns
25	RAS Precharge Time	t <sub>RSP</sub>	11	3tc-10	—	ns
26	CS Delay Time 1	t <sub>CSDL</sub>	11	—	15	ns
27	OE Delay Time 1	t <sub>OED1</sub>	11	—	15	ns
28	2CLK Delay Time from OE	t <sub>2CKD</sub>	11	0	10	ns
29	Valid MAD0-MA19 to Valid Low Address Delay Time	t <sub>RAD</sub>	11	—	25	ns
30	Column Address Delay Time	t <sub>CAD</sub>	11	5	25	ns
31	FD Setup Time	t <sub>FDS</sub>	11	8	—	ns
32	FD Hold Time 1	t <sub>FDH1</sub>	11	5	—	ns
33	FD Hold Time 2	t <sub>FDH2</sub>	11	2	—	ns
34	Valid FD to Valid MAD Delay	t <sub>MADV</sub>	11	—	10	ns
35	Read Data Turn on Time	t <sub>RDTV</sub>	11	0	—	ns
36	Read Data Hold Time	t <sub>RDH</sub>	11	3	—	ns



**AC Characteristics (cont)**(V<sub>CC</sub> = 5.0 V ± 5%, V<sub>SS</sub> = 0 V, Ta = 0 to +70°C unless otherwise noted.)

No.	Item	Symbol	Reference Figure#	Min	Max	Unit
37	WE Delay Time	t <sub>WED</sub>	14	—	25	ns
38	WE Low Pulse Width	t <sub>WLW</sub>	14	tc-15	—	ns
39	WE High Pulse Width	t <sub>WHW</sub>	14	tc-15	—	ns
40	CE low to WE Pulse Width	t <sub>CWEW</sub>	14	tc-15	—	ns
41	Draw Write Data Setup Time	t <sub>WDS</sub>	14	15	—	ns
42	FD Delay Time 1	t <sub>FDD1</sub>	14	—	20	ns
43	FD Delay Time 2	t <sub>FDD2</sub>	14	—	20	ns
44	WE/CS Low to FD Hold Time	t <sub>WFDHW</sub>	14	tc-10	—	ns
45	WE/CS Low to Address Hold	t <sub>WAHW</sub>	14	tc-5	—	ns
46	FD Hold Time	t <sub>FDHW</sub>	14	0	—	ns
47	FD Turn Off Time	t <sub>FDTI</sub>	14	—	50	ns
48	VSYNC/2 Delay Time	t <sub>VS2D</sub>	11	—	25	ns
49	DOTCLK Delay Time	t <sub>DCD</sub>	11	—	15	ns
50	VIDEO Delay Time	t <sub>VD</sub>	11	-5	5	ns
51	BL2IRQ Delay Time	t <sub>IRQD</sub>	20	—	10	ns
52	IRQCLR to BL2IRQ Clear Delay Time	t <sub>IRQCD</sub>	20	—	20	ns
53	SHFTEN Delay Time	t <sub>SFTEND</sub>	11	-5	5	ns

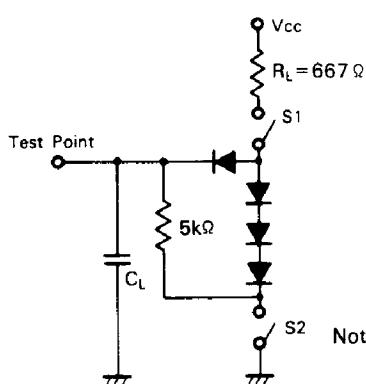
## Test Circuit



Signal	CL (pF)
2CLK	
DOTCK	
VSYNC/2	
RAS	
CS	
WE	40
OE	
FA0-FA9	
VIDEOA-VIDEOB	
SHFTEN	
BL2IRQ	

Note: All diodes are 1S2074's or the equivalent.

(a) Totem Pole Output



Signal	CL (pF)
MAD0-MAD15	40
FD0-FD7	

Note: All diodes are 1S2074's or the equivalent.

(b) Three State Output

**Reference**

<b>Display Data Fetch</b>	<b>Memory Chip</b>	<b>Cycle Mode</b>	<b>Figure No.</b>
4 Fetch/1 MCYC	1 Chip	Drawing Read Cycle	11
		Drawing Write Cycle	14
		Display Cycle	17
		Refresh & Attribute Cycle	20
	2 Chips	Drawing Read Cycle	12
		Drawing Write Cycle	15
		Display Cycle	17
		Refresh & Attribute Cycle	20
	4 Chips	Drawing Read Cycle	13
		Drawing Write Cycle	16
		Display Cycle	18
		Refresh & Attribute Cycle	20
16 Fetch/2 MCYC	1 Chips	Drawing Read Cycle	11
		Drawing Write Cycle	14
		Display Cycle	19
		Refresh & Attribute Cycle	20
	2 Chips	Drawing Read Cycle	12
		Drawing Write Cycle	15
		Display Cycle	19
		Refresh & Attribute Cycle	20



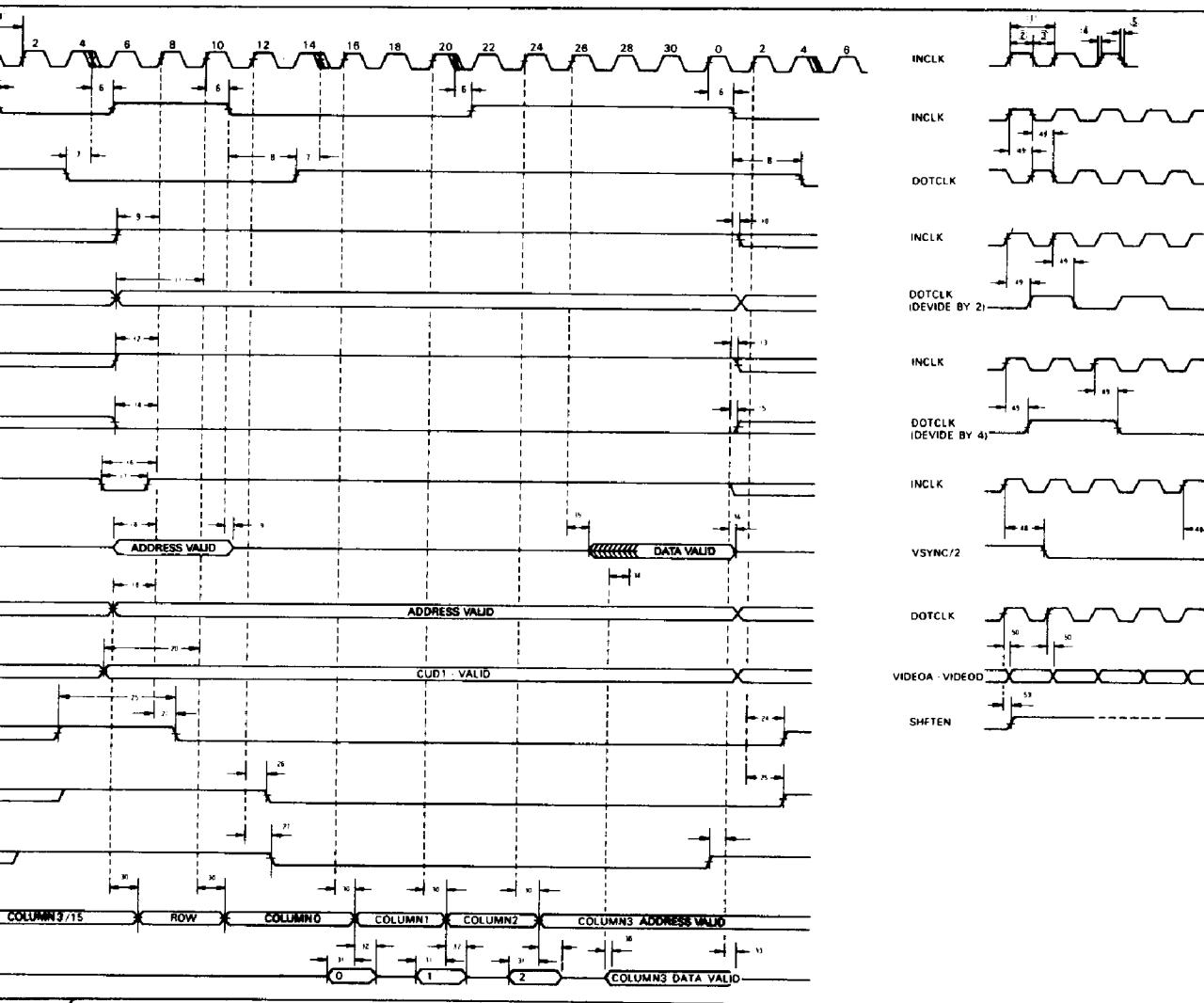
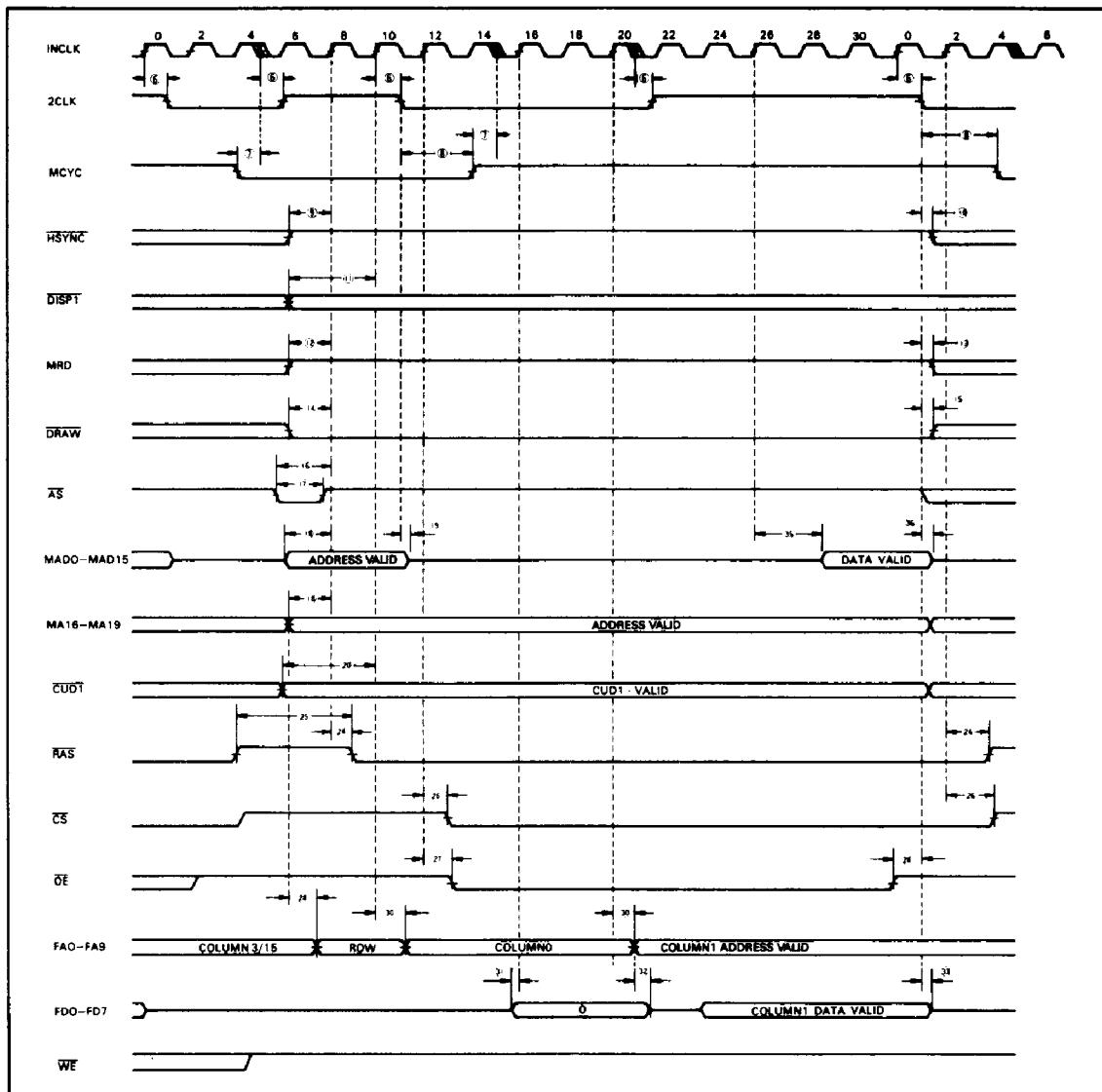


Figure 11. 1MCYC Draw Read (1 Chip)



**Figure 12. 1MCYC Draw Read (2 Chip)**

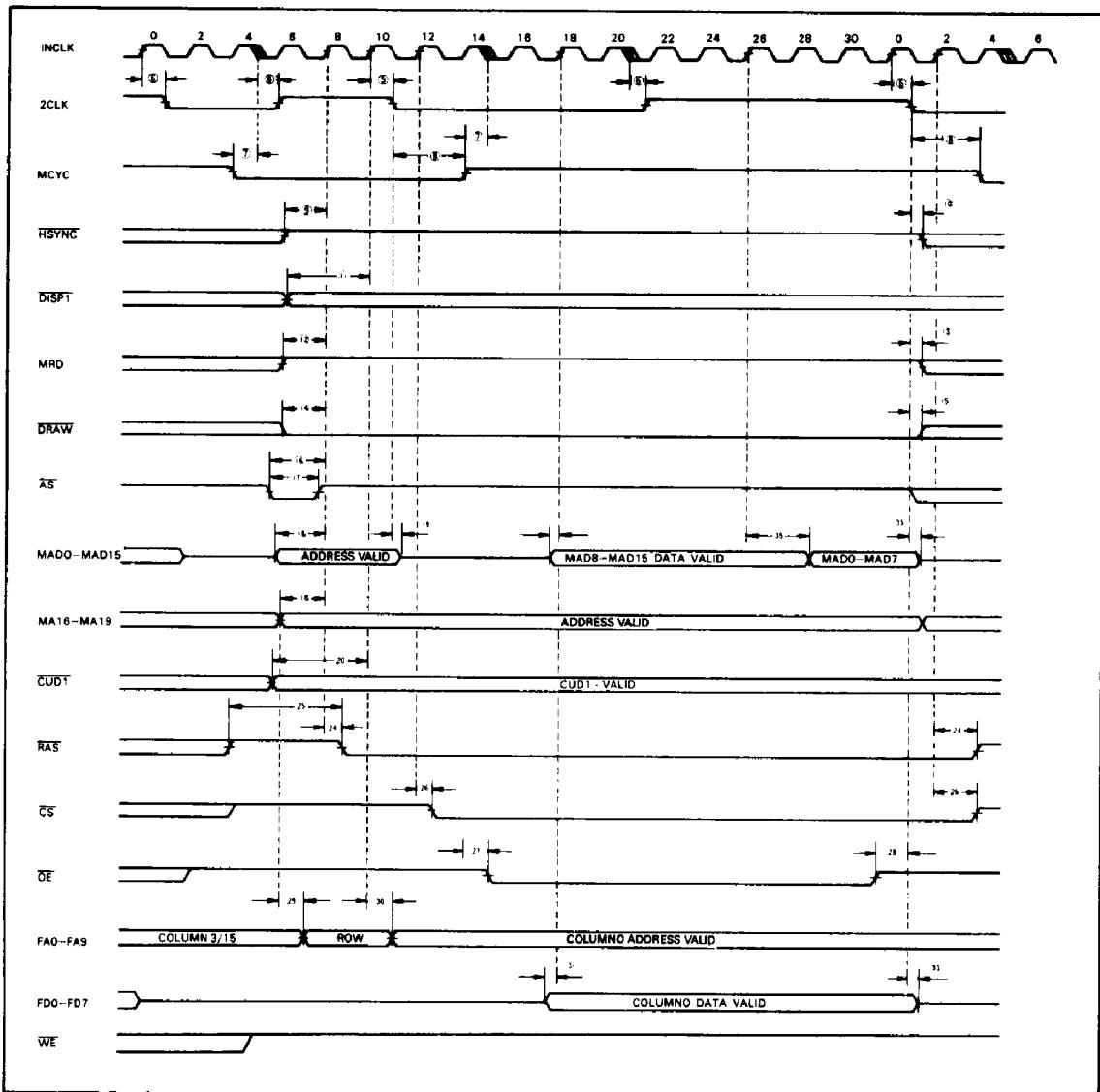
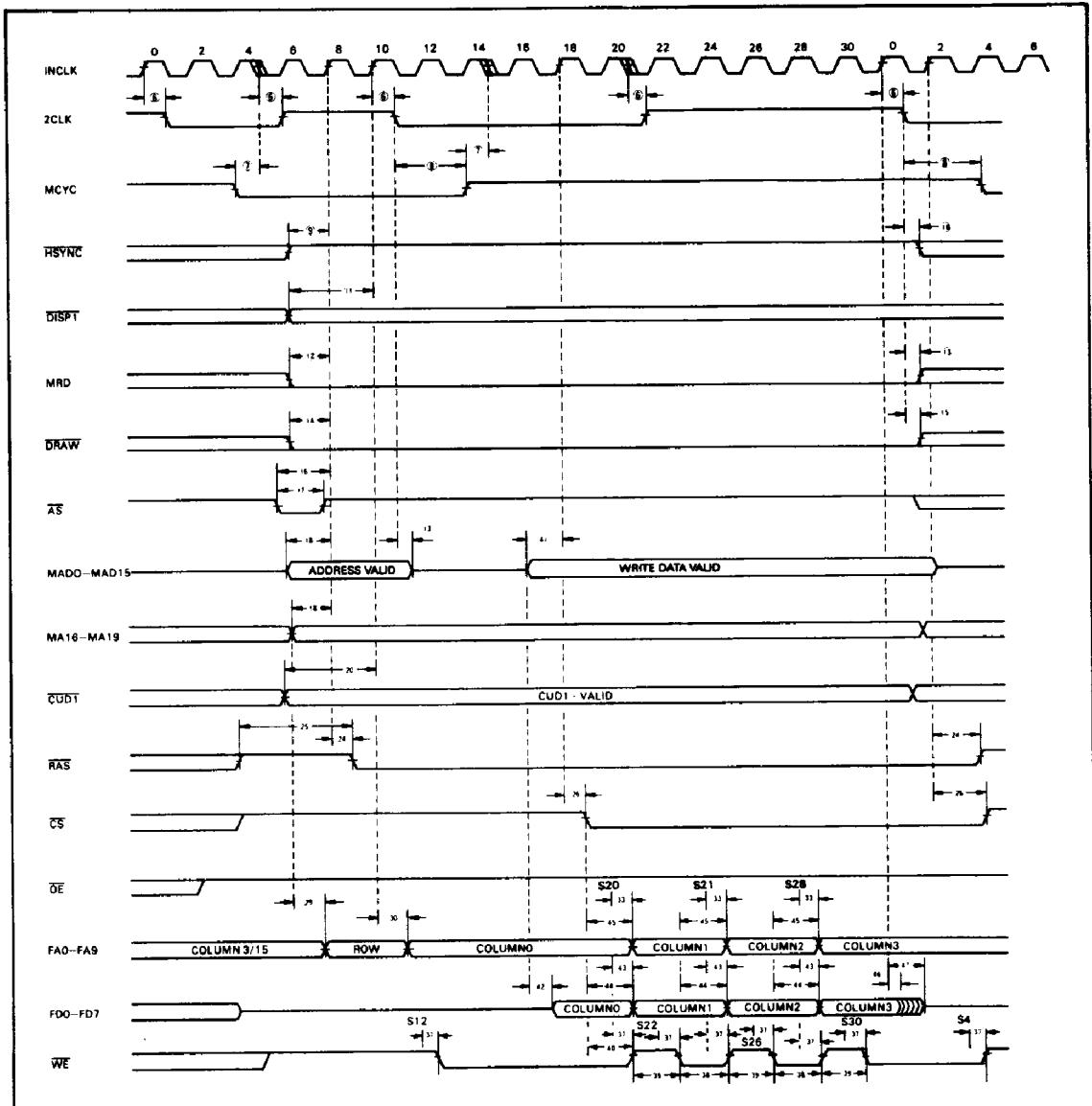


Figure 13. 1MCYC Draw Read (4 Chip)



**Figure 14. 1MCYC Draw Write (1 Chip)**

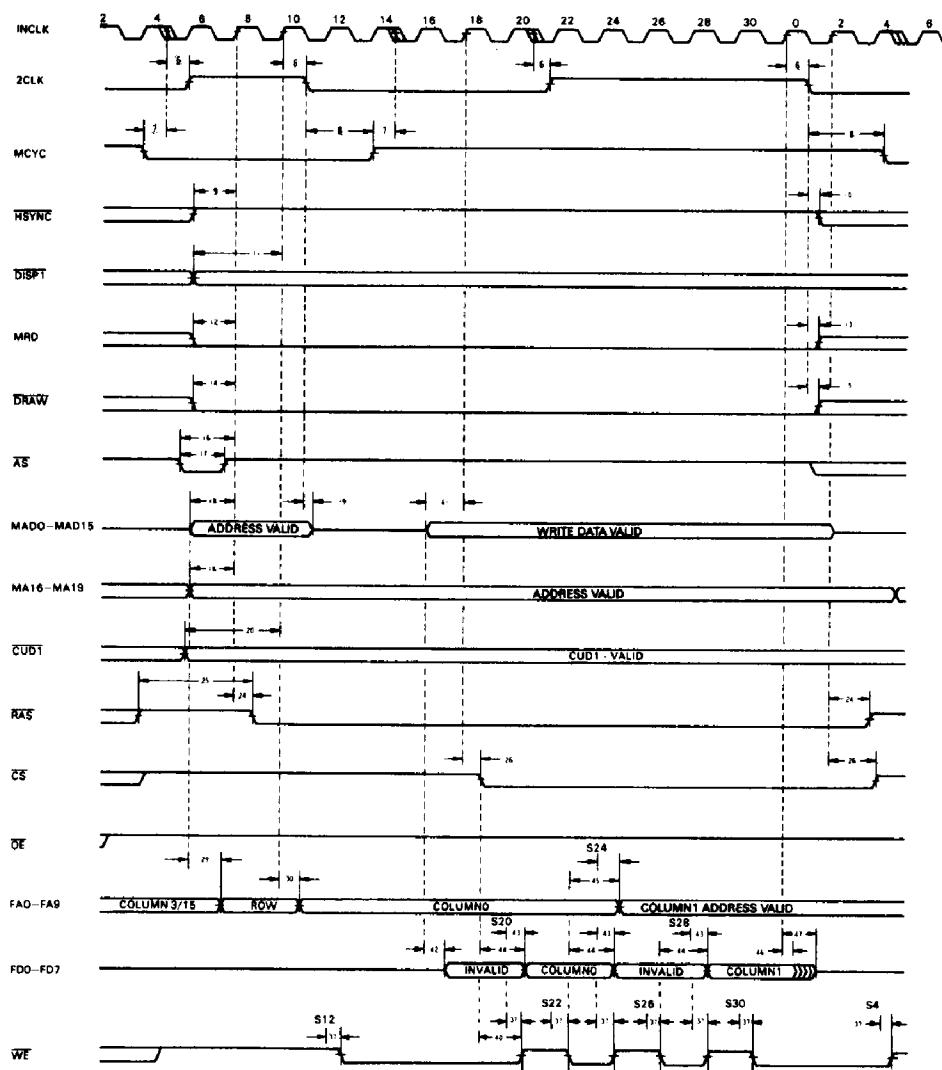


Figure 15. 1MCYC Draw Write (2 Chip)

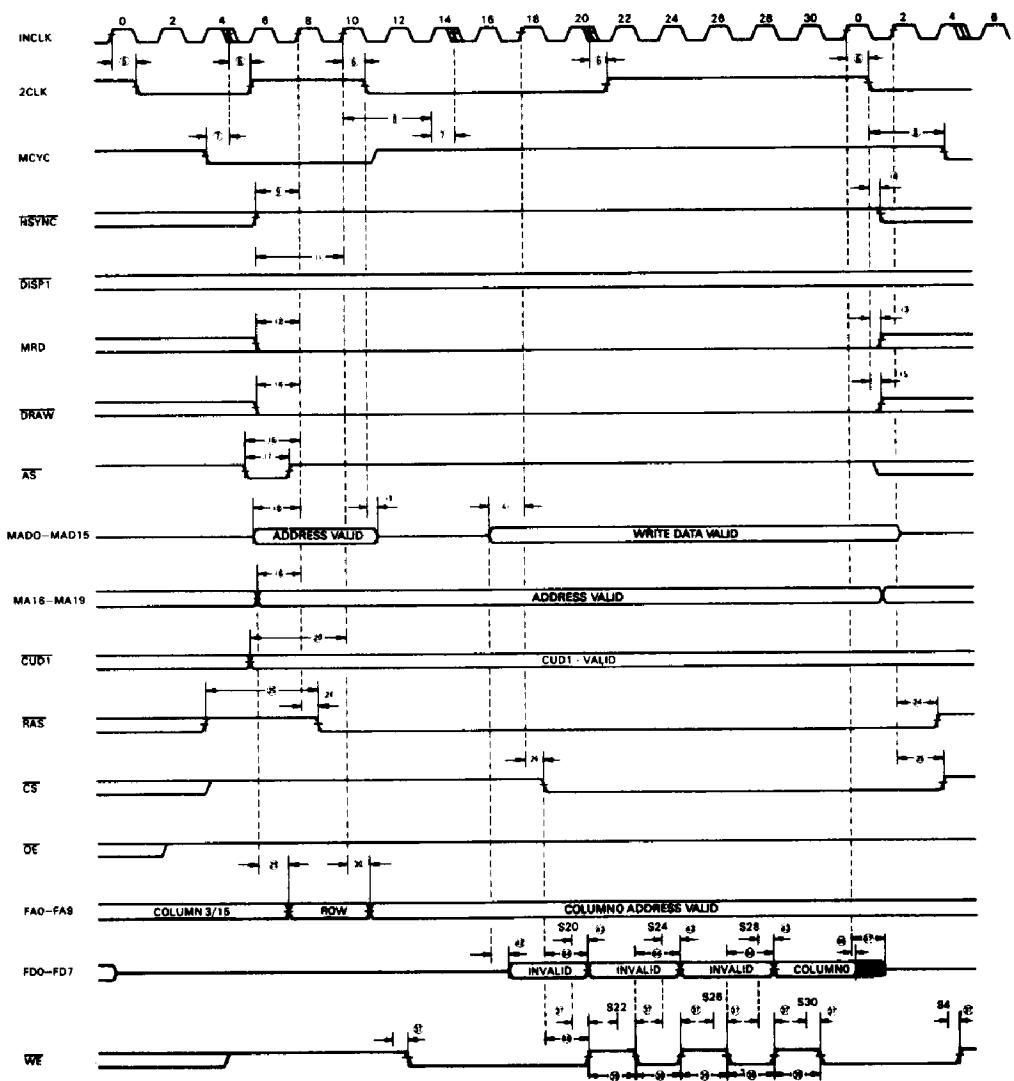
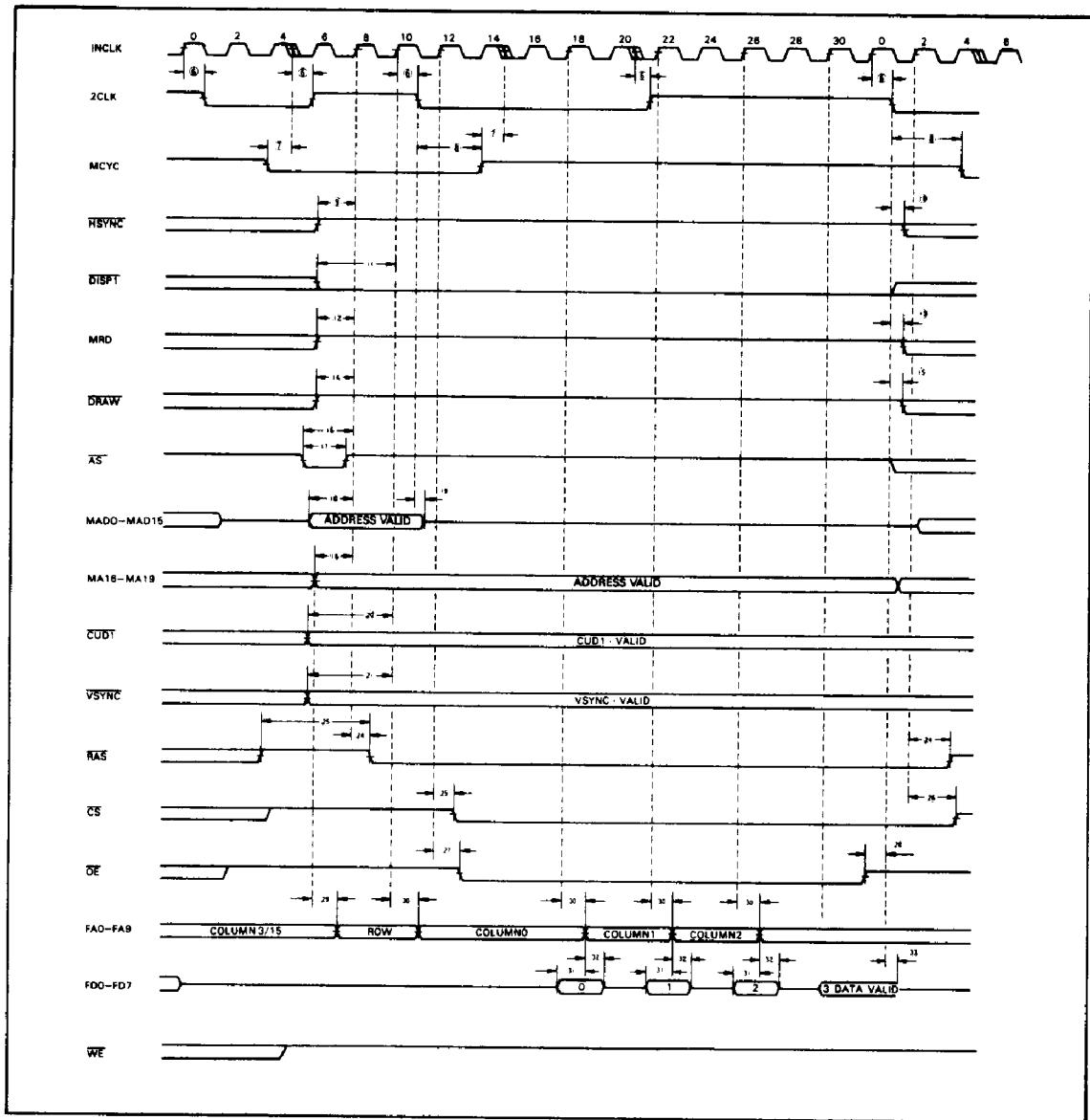


Figure 16. 1MCYC Draw Write (4 Chip)



**Figure 17. 1MCYC Display Read (1 or 2 Chip)**

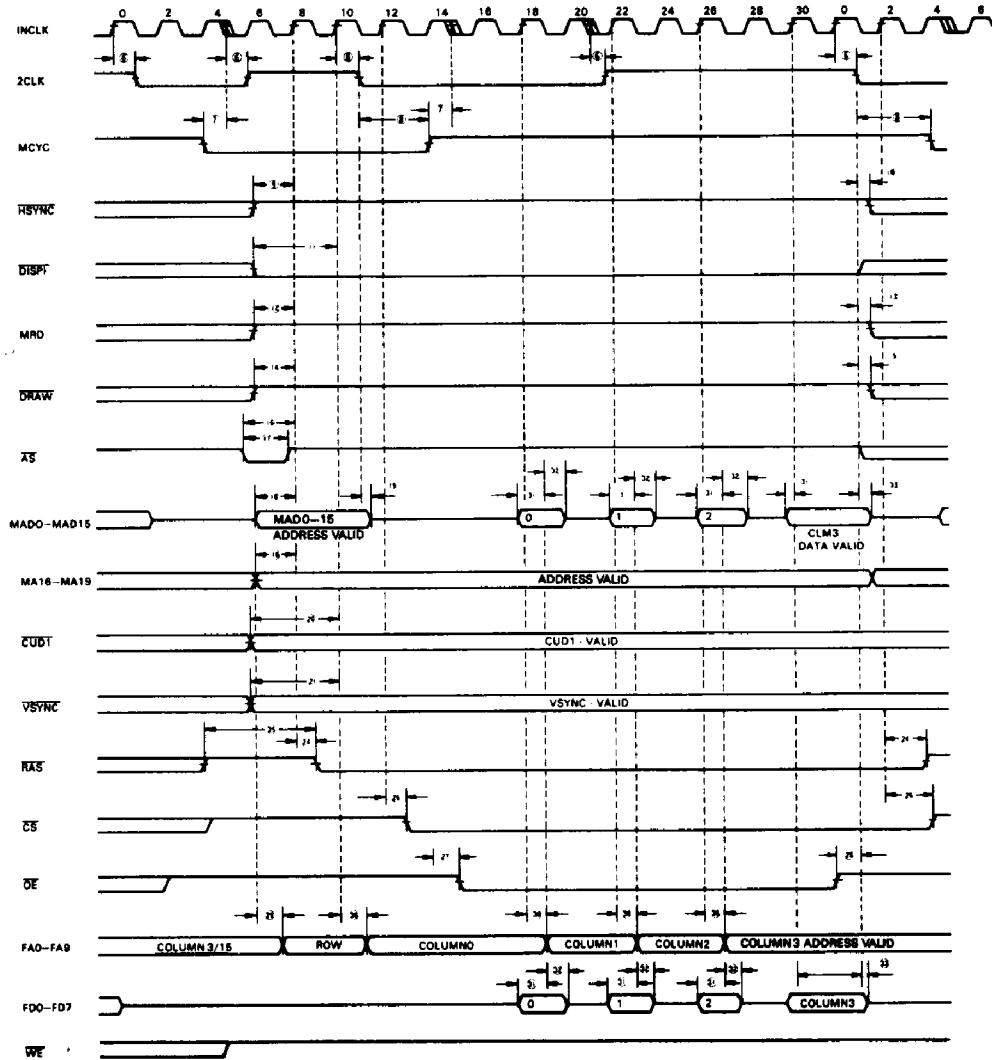


Figure 18. 1MCYC Display Read (4 Chip)

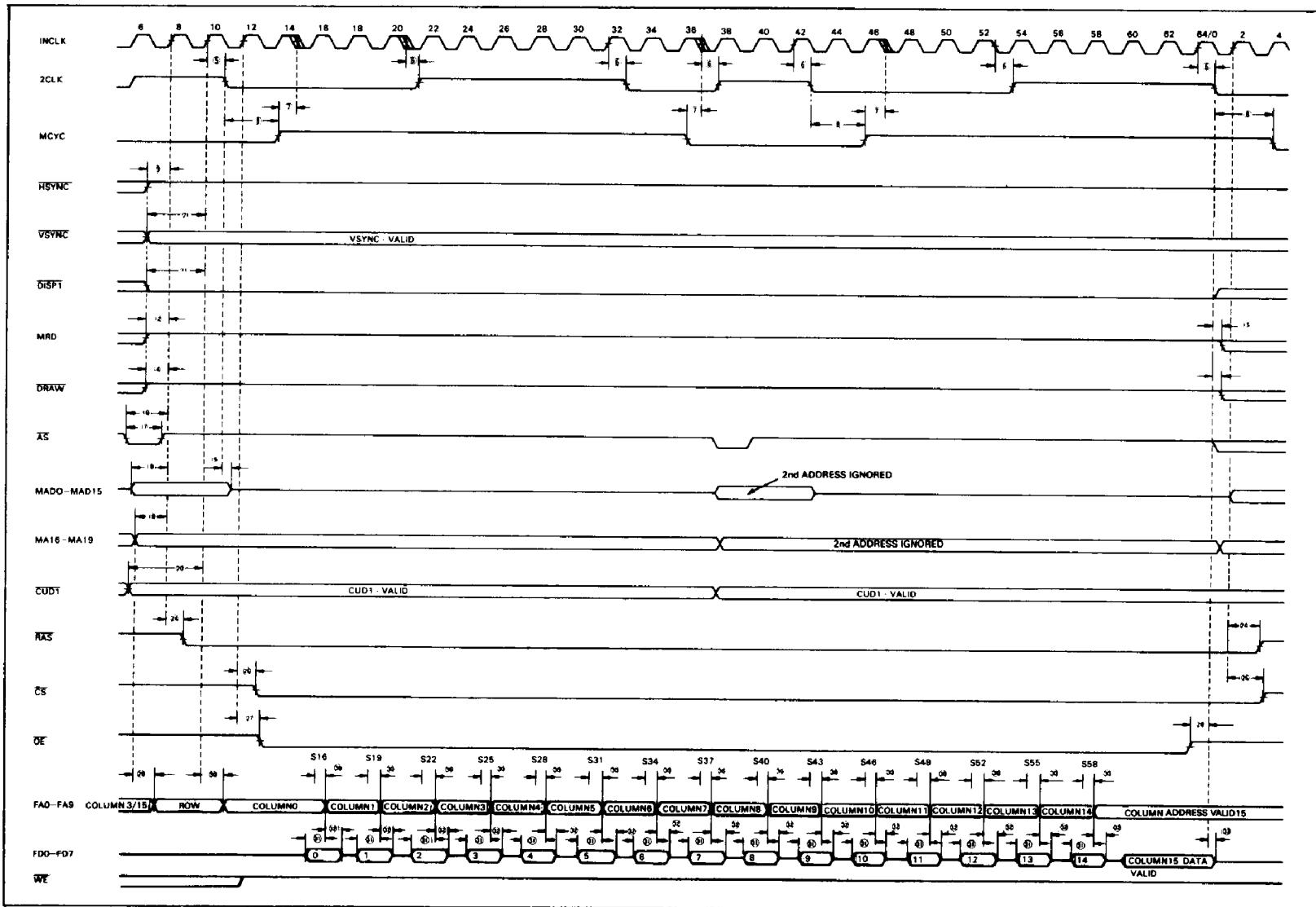


Figure 19. 1MCYC Display Read (1 or 2 Chip)

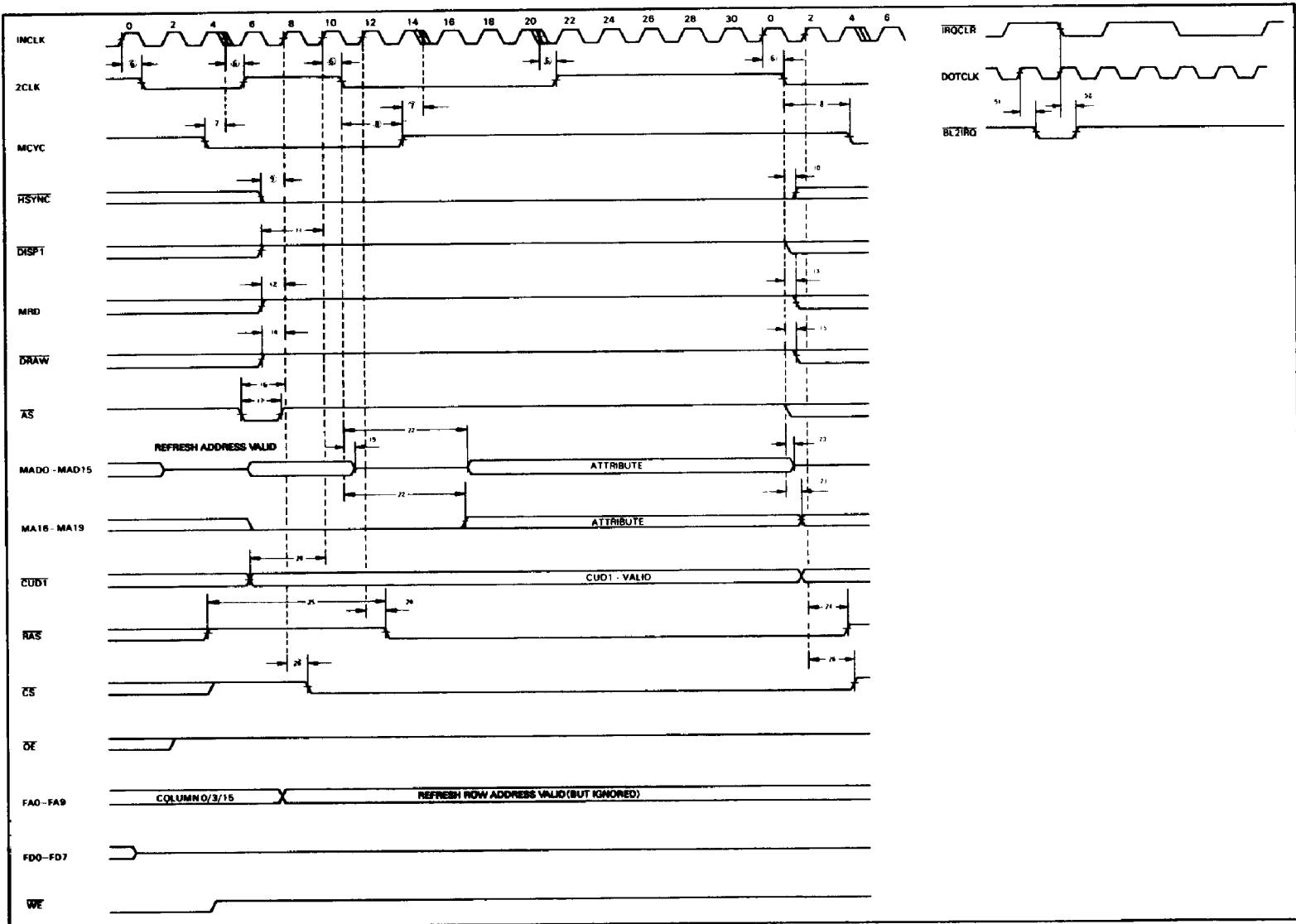


Figure 20. CS before RAS Refresh

Refer to application note (No. ADE-507-001) for detail of this product.